The Effectiveness of Gamification for Students' Engagement in Technical and Vocational Education and Training

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***Abstract*—The transformation of Technical and Vocational Education and Training (TVET) prioritizes by the national education convention to meet the needs of the industry through improving student skills and the quality of related systems. One of the transformations is practicing blended learning, such as a flipped classroom, to produce better quality student learning outcomes. However, based on previous studies, there are difficulties in maintaining student engagement during learning activities, even though blended learning offers some advantages. Therefore, this study suggests the development of a mobile application using gamification as a solution to enhance student participation. This paper proposes the design and development research (DDR) approach with the adaptation of the ADDIE model to build a learning content prototype. It involves five phases: analysis, design, development, implementation, and evaluation. The study participants consisted of two groups of students in the 1st semester of the Interactive Multimedia course from two different TVET institutions who were cleft into a control group and an experimental group. The experimental group is gamified, whereas the control group is not. The study evaluation uses two instruments: a test to compare students' understanding of both groups and an activity log to track the experimental group's use of the prototype. According to the findings, gamification during learning activities can increase student engagement by boosting performance through a more significant pre-and post-test mean score difference and creating a positive learning experience. Additionally, mobile applications with the gamification concept can be employed extensively in various TVET courses to encourage student learning performance.**

Keywords*—Technical and vocational education and training (TVET); flipped classroom; engagement; gamification; mobile application

I. Introduction

UNESCO defines Technical and Vocational Education and Training (TVET) as a term that refers to aspects of education. It involves alternatives to academic education, the study of technology and related sciences, and an environment to acquire and apply knowledge, skills, and attitudes related to employment in various sectors of the economy and social life. The measurement of TVET students' competence refers to job analysis developed through the coordination of industry experts, skilled workers, and teaching experts by field to ensure that the implementation of TVET meets and is in line with the needs of the industry [1].

Various approaches are used during learning activities to guarantee that students attain the essential competencies, one of which is blended learning. Blended learning is a blend of face-to-face or online learning activities that occur inside or outside of the classroom, such as conversations in group work, hands-on practice, presentations, and project-based solutions [2]. It was detected to be more successful at enhancing student engagement.

Although blended learning has a positive effect on student engagement, according to [3], there are difficulties in maintaining it. To sustain engagement potential and achieve learning objectives, students must be wise in how well they manage their attitude and autonomy during learning activities.

According to previous studies, gamification has been widely used in TVET, albeit it is unclear whether this manages to boost engagement [4]. Therefore, this study suggests developing a mobile application using gamification as a solution to assess student engagement by their achievement and learning experiences. Since students spend most of their time on their phones, mobile applications have emerged as the best way to motivate them to learn.

The implementation of this study is vital in contributing towards:

- Make students engage in learning activities through gamification to increase student performance and reduce the dropout rate.
- It adds to research on the wide use of gamification in the TVET environment but is less prominent.
- It can be extended to the entire TVET, whether public or private TVET institutions, in various areas of TVET.

II. Literature Review

This section explains the synthesis of information obtained to assess student engagement in TVET blended learning through gamification. It is divided into several parts, starting with the introduction to TVET, the flipped classroom practiced in TVET institutions, the potential of student engagement in

learning activities, and the use of gamification elements to develop mobile application prototypes for self-learning.

A. Technical and Vocational Education and Training (TVET)

TVET plays a role in producing a skilled workforce in various fields through training that allows students to acquire knowledge and skills. It shapes students to have a lifelong learning mindset and be capable as employers who create jobs. TVET also provides individuals with expertise and skills appropriate to the job market to address the global unemployment problem that will produce competent and creative workers who function as agents of sustainability in the workplace [5].

Several aspects need to consider for effective TVET implementation listed as:

- The use and influence of technology in learning activities, like the importance of ICT to solve problems creatively and analytically through various applications, software, and devices [5].
- Instructors' preparation ensures that learning activities efficiently run where they need to master the knowledge and skills in the field by being able to explain and demonstrate correct and safe work steps and answer any questions from students [6].
- TVET-related systems are understood and implemented by all parties, for example, using job analysis correctly as a reference to carry out the learning process along with the right equipment, work steps, and technical information arranged according to the difficulty level [1].

Aspects mentioned, such as the influence of ICT, teacher preparation, and the system set, encourage the diversity of the implementation of learning activities in the TVET environment. One method that has gained attention is blended learning, which meets TVET learning activities by emphasizing specific jobs' theoretical and practical components. The following section will discuss blended learning.

B. Flipped Classroom

The learning environment needs to provide space for communication, collaboration, creativity, and critical thinking in making decisions, developing strategies, and solving problems with the help of technology [7]. This conducive condition is necessary to avoid boredom that limits the ability to perform tasks and creates a feeling of lack of interest, loss of motivation, and absence of student engagement [8].

Therefore, TVET practices blended learning to create a conducive learning environment. A famous example of blended learning is the flipped classroom. Students prepare beforehand using learning materials such as presentation slides or videos before undergoing face-to-face learning with instructor monitoring through various activities such as discussions, presentations, drills, group assignments, and assessments [8].

Comparison between flipped and traditional classrooms is the better way to understand it. Implementing a conventional classroom is through the delivery of learning content by the instructor in the class at a set time and period. Then students must complete the tasks provided after the end of the study [9]. Meanwhile, flipped classroom implementation contradicts traditional classrooms, as shown in Fig. 1.

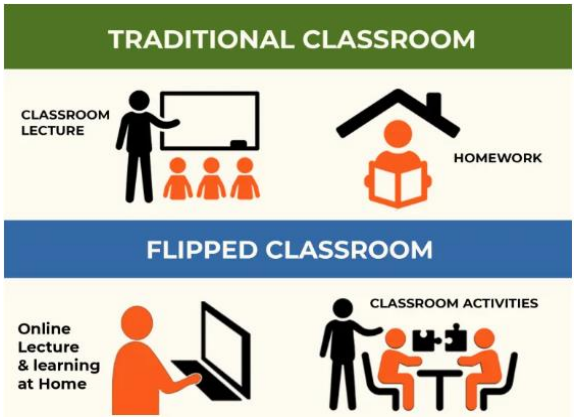

Fig. 1. Traditional Versus Flipped Classroom (Source: https://edtechimpact.com/news/flipping-the-classroom-ultimate-guide).

Although blended learning practices in the TVET environment positively impact students, engagement is challenging to maintain. This hardship pushes by several factors, such as the diversity of student characters, less effective learning materials, and constraints in the use of learning technology. The next section of the literature answers several points related to student engagement in learning activities.

C. Engagement

The foundation of high-quality learning is engagement, defined as the use of time and energy to carry out an action or task differently impacted by many circumstances [10]. Students' good attendance, commitment, interaction in learning activities [11], and valuable personalities, including satisfaction, success, belonging, enjoyment, liking, skills, competence, perseverance, motivation, and courage, are examples of engagement [4] [12].

Student engagement in learning activities is measured using numerous instruments related to various items. Some use the National Survey of Student Engagement (NSSE), K-12 classroom engagement scale, Student Engagement Questionnaire (SEQ), and a combination of positive and negative affect schedule and presence questionnaires [13]. However, most of the instruments employed focus on the three main measurement criteria' behavioral, cognitive, and emotional.

Behavioral criteria were discovered by looking at how engaged and diligent students are in their studies and how willing they are to ask for assistance when necessary [14]. These criteria also affect utilizing qualitative elements that require effort, attention, and persistence while being observed [4].

Cognitive criteria implicate the amount of effort and time required to comprehend the work, the drive to overcome shortcomings, the ease with which one can adjust to problem-

solving, and the achievement of learning success [14]. For easier understanding, this criterion requires efforts of academic knowledge's intellectual components [15].

Emotional criteria are determined by looking at positive emotions, such as excitement, joy, and confidence, as well as negative ones, such as boredom, frustration, and anxiety [13]. It also measures expression through feelings or reactions between a combination of physiological and psychomotor components positively or negatively, including pride and anger [4].

When implementing learning activities, it can be troublesome to keep students' attention because they come from different backgrounds and have different learning styles. Hence, it is necessary to set difficulty levels starting with easy, medium, and challenging levels throughout learning activities [16].

How can engagement be maintained to ensure learning activities achieve the set learning outcomes? This question is always floating around, and the implementation of various methods to address this issue. One way is using gamification in learning activities described in detail in the next section.

D. Gamification

Instructors are continually experimenting with a new pedagogical method to capture students' attention, motivate them, and engage them in learning activities. Thus, rather than traditional learning methods, digital computer games are customized to create an enjoyable and engaging learning environment for students [17]. The adaptation of a game into a non-game condition is key to gamification. As a result, the definition of gamification is the use of game elements or mechanics in non-game contexts [18].

Explicit knowledge is required when comparing gamification in learning activities to other methods that also use the basics of games, such as game-based learning (GBL), serious games, and simulations. GBL employs the power of games to engage students in learning activities [19]. On the other hand, serious games resemble gaming design worlds that solve problems unrelated to enjoyment [20]. While the simulation parallels a serious game, the main objective is training in the military, medicine, and aviation fields [17].

Gamification includes a variety of qualities that help it achieve its purpose. It provides rewards and develops motivation [21] to complete specific tasks. It makes learning material more dynamic, innovative, and appealing, encouraging participation and boosting understanding of the learning substances [22]. It promotes various active and successful learning strategies by maintaining attention and interest in all learning tasks [23]. It can also be an alternate strategy that adds value to normal learning activities by giving a more engaging experience through gamification elements [14]. Furthermore, gamification persuades students to complete assignments despite exhaustion [17].

Gamification aims to lower dropout rates by providing students with practical learning methods and creating a pleasant learning environment [22]. It can increase students' enjoyment and engagement to kindle their interest in studying and obtain better results [21]. It can motivate and encourage student competitiveness by improving student happiness, effectiveness, and efficiency in learning activities [14]. When students face challenging topics and limited time, it eliminates challenges and solves problems during learning activities by integrating learning activities appropriately [18].

Application developers and instructors must work together to ensure that the gamification design delivers maximum benefits and effectively enhances student engagement [10]. One of the primary design criteria is incorporating relevant and purposeful gamification elements into the learning content via set objectives. By delivering clear, intuitive, and pleasant learning content, gamification elements should generate a good learning experience [21]. Table I depicts the use of gamification elements related to student engagement based on previous studies.

Besides that, gamification interface design must incorporate seamless navigation [21], an exciting narrative adjustment, and an acceptable combination of text, graphics, colors, and animations [17]. It is to ensure that students do not lose focus due to the excessive amount of gamification design so that they stray from the original learning goal [24]. The processing of learning content into gamification design needs to emphasize learning strategies so that students obtain quality learning results and experiences. Among the techniques practiced is segmentation, which breaks down learning material at a rate students can accept for knowledge retention [25]. The arrangement of learning content also needs to follow levels starting from low, medium, and high levels to meet the needs and abilities of students from various backgrounds [17].

The coming section explains the research methodology based on the problem statement and literature review. This section details the steps implemented to develop a mobile learning application prototype by including gamification elements identified to increase student engagement.

TABLE I. GAMIFICATION ELEMENTS RELATED TO STUDENT ENGAGEMENT BASED ON PREVIOUS STUDIES

Gamification elements	**Source**											
	[4]	***[10]***	***[11]***	***[14]***	***[15]***	***[17]***	***[18]***	***[19]***	***[21]***	***[22]***	***[23]***	***[24]***
Badges		X	X		X		X	X	X			
Challenges		X							X			
Leaderboard	X								X			
Leveling	X	X	X		X		X	X	X	X		X
Points	X	X	X		X		X	X	X	X	X	X
Unlock content									X			
Avatar		X								X		
Progress bar	X		X		X			X		X		
Rewards/ Awards				X		X	X			X	X	
Feedback			X	X	X	X						
Time pressure/ limit			X		X			X				X
Life											X	

III. METHODOLOGY

The study employs experiential learning theory, an essential theory based on cognitive results. This theory states that learning activities repeatedly occur through experience modification, observational reflection, abstract conceptualization, and active experimentation [26]. The repeating process is made feasible by learning exercises over a developed gamified mobile app prototype. The study occupies the design and development research (DDR) approach with the adaptation of the ADDIE model depicted in Fig. 2.

The selection of DDR as a research methodology is because DDR involves a systematic and organized process consisting of three stages: designing, developing, and evaluating the success of mobile learning application prototypes to obtain empirical evidence based on the collection and analysis of data from experiments conducted. The adapted ADDIE model into DDR consists of five phases: analysis, design, development, implementation, and evaluation, which are explained in more detail hereafter.

A. Analysis Phase

The analysis phase involves the analysis and setting of some criteria to launch the implementation of the study. It determines study participants, prototype users, learning content, and authoring tools with appropriate gamification elements.

The participants chosen were first-semester students' of Software Technology (Interactive Multimedia) from two different TVET institutions split into a control group and an experimental group. Both groups underwent face-to-face, blended learning activities, while only the experimental group had to use the gamified prototype as an addition to self-learning.

The module as the prototype's content is Image Editing from the five available modules. The topics involved are shooting, selecting, editing, and saving photos. It is used with the instructor's help to optimize characteristics of knowledge, abilities, and attitudes in the prototype.

Furthermore, the selection of proper authoring tools ensures that the process of producing and testing the prototype achieves the study's goal. The research uses Buildbox software because it offers prototyping features with an excellent 2D graphic resolution display, appropriate gamification elements, and the drag-and-drop concept.

B. Design Phase

The prototype consists of four main parts according to sub-topics: notes, quizzes, assessments, and games. The prototype's content should comply with the TVET learning environment, including knowledge, skills, and attitude competencies. As in Table II, prototypes are developed by including eight gamification elements to trigger student engagement.

The prototype also applies Mayer's multimedia design principles to support learning activities to be more quality and effective. It also uses Jakob Nielsen's heuristic evaluation to ensure the display of the prototype works well.

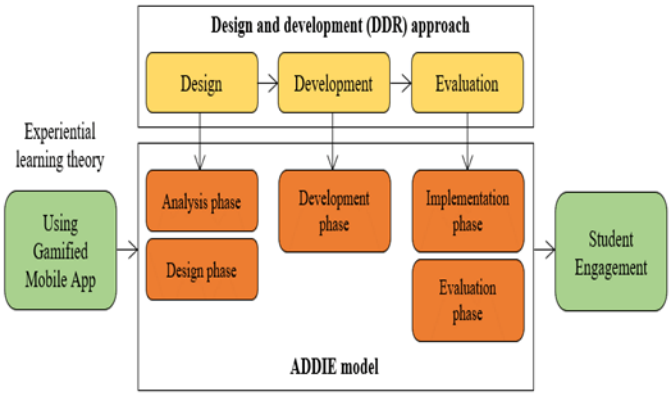

Fig. 2. DDR Approach with the Adaption of the ADDIE Model.

TABLE II. GAMIFICATION ELEMENTS USED IN THE PROTOTYPE

Part	Gamification elements	Function
Notes	Leveling$_1$	Before moving on to the subsequent sub-topic, be sure the sub-topic before has been finished.
	Progress bar$_2$	Disclose the progress status of the reviewing notes.
	Badges$_3$	The current sub-topic was reviewed and determined to be ready for a quiz or progression to the next sub-topic.
Quizzes	Points$_4$	Answers earn points. If the answer is correct, points count; if incorrect, no points count.
	Feedback$_5$	Feedback is provided based on answers. If the answer is correct, proceed to the next question. The necessary notes are displayed if the answer is incorrect and returned to the current question.
	Life$_6$	Life is permitted to provide answers. If the answer is incorrect, life deducts, and students repeat the quiz if there is no more life.
	Leveling$_1$	Students must earn all possible points to be qualified to respond to the assessment question or go on to the following subtopic.
Assessments	Time limit$_7$	Allow time to respond to questions. No points if the timer ran out and skipped the question.
	Points$_4$	Answers earn points. If the answer is correct, points count; if incorrect, no points count.
	Leveling$_1$	Must complete specific parts (notes and quizzes) to be qualified to respond to the following assessment question.
Games	Challenges$_8$	Make the game challenging by requiring players to collect and avoid specific things.
	Life$_6$	Set up a gaming environment. Failure to dodge obstacles results in reduced life, and when life is gone, the game is over.
	Points$_4$	Make a competition within the game to increase current points for the next round.

[a.] Total of gamification used: 1,2,3,4,5,6,7,8

Fig. 3. Some Prototype Interfaces that Incorporate Gamification Elements.

The quizzes and assessments structure meets the criteria of difficulty level and skill type formed through the Test Specification Table. The difficulty level refers to the value of the question hardship starting from low, medium, and high based on the student's ability to answer the question using the ratio 1 (low): 2 (medium): 1 (high). In contrast, the skill type refers to a category built on three aspects, consisting of theoretical, procedural, and attitude parts, using the ratio 6 (theory): 3 (procedure): 1 (attitude).

The game intends to give students a space to rest for a while from entirely focusing on learning activities through other parts of this prototype. However, the game produced revolves around graphics related to the learning material.

C. Development Phase

This phase entails forming a prototype and continual testing to guarantee that it is functional. The prototype pre-use is a series of usability tests conducted with students, instructors, and developer experts utilizing the thinking-aloud method. Each examiner made a clear vocal comment while using the prototype, and the researcher recorded the statements.

Visual and functional characteristics that affect prototype performance, such as appropriateness and precision of navigation, clear writing, quality visuals, effective interface display, and efficient learning content, are reviewed. Fig. 3 depicts some prototype interfaces that incorporate gamification elements.

D. Implementation Phase

The implementation phase includes a pre-test followed by the prototype usage within a specific time frame and ending with a post-test by 23 students in each group. The pre-and post-tests use the 40 same multiple choice questions (MCQ) in different positions to assess student comprehension.

The experimental groups (prototype users) must update the activity logs within two weeks of utilizing the prototype. This step intends to reduce the possibility of students becoming disinterested in self-learning. Meanwhile, the control group only underwent blended learning activities with the instructors.

The activity logs provided the student's prototype progress throughout the self-study session. Students only answer the items provided through yes or no options, record the date for each stage, and answer a few short questions. Intending to make it easier for students to provide the necessary information, gain initial exposure related to the prototype content, and allows students to focus while using this prototype.

E. Evaluation Phase

The evaluation phase is the study's final stage to determine gamification's effectiveness on student engagement in TVET blended learning. Evaluation of the construction of a hypothesis is conducted based on pre-and post-test scores as follows:

- h_0 – no significant difference between the pre-test and post-test scores of the control group
- h_1 – no significant difference between the pre-test and post-test scores of the experimental group

In addition to the hypothesis findings, the study also analyzed the activity log updated by the experimental group.

IV. Results

A. Pre-and Post-Test Scores

A quantitative analysis was conducted on the pre-and post-test scores by a total of 46 students from both control and experimental groups using SPSS software. Before the execution of the investigation on the constructed hypothesis, a normality test runs on the entire score obtained to determine the normal distribution of the scores. Table III shows the Shapiro-Wilk normality test results for the control and experimental groups' pre-and post-tests.

TABLE III. Shapiro-Wilk Normality Test Results

Group	Test	Statistic	df	Sig
Control	Pre	0.954	23	**0.545**
	Post	0.956	23	**0.389**
Experimental	Pre	0.923	23	**0.079**
	Post	0.953	23	**0.342**

Based on the table shown that the Shapiro-Wilk value for the entire score is determined as normally distributed with a significant rate of $p>0.05$. As a result, parametric tests can be performed based on the overall score.

A paired sample t-test was conducted on pre-and post-test scores to prove the hypothesis built based on a significant value of $p<0.05$ as follows:

- "h_0 – no significant difference between the pre-test and post-test scores of the control group". Value $p=0.001$, then h_0 – rejected.
- "h_1 – no significant difference between the pre-test and post-test scores of the experimental group". Value $p=0.001$, then h_1 – rejected.

Depending on the paired sample t-test, hypotheses were all rejected because significant differences between the tested variables showed that student understanding increased between the pre-and post-test. However, the improvement achieved by students from the experimental group using gamified application prototypes is more remarkable through a mean difference of 17.52, referring to Table IV. This difference demonstrates that gamification affects student engagement in self-learning by leading to higher learning outcomes.

TABLE IV. THE PRE-AND POST-TEST MEAN DIFFERENCE

Group	Test	Mean Score	Mean score difference
Control	Pre	20.09	9.95
	Post	30.04	
Experimental	Pre	17.83	**17.52**
	Post	35.35	

B. Gamified Activity Logs Analysis

An analysis enforced three criteria to analyze the activity logs amended by prototype users. It includes cognitive, behavioral, and emotional factors related to gamification elements influencing student engagement during learning activities. Table V summarizes the activity log's findings through gamification elements.

The gamification design is also vital in boosting the quality of learning activities. Table VI summarizes the engagement measurement of different gamification designs used in the prototype.

TABLE V. THE ACTIVITY LOG'S FINDINGS THROUGH GAMIFICATION ELEMENTS

Assessment criteria	Assessment item	Worksheet item	Finding	Result
Cognitive	Learning repetition	How many attempts to earn full marks when answering the quiz to be eligible to answer the assessment?	The mean of quiz repetitions is 3.32 times.	There is engagement through the retention of knowledge due to the repetition of learning activities.
		Do you read finished notes repeatedly?	100% answered Yes.	
		Did you repeat the completed assessment to improve the score obtained?	100% answered Yes.	
	Assessment score	The obtained score while answering the assessment.	The assessment mean of scores is 7.85 compared to 10 questions for each sub-topic.	There is engagement through good scores while undergoing assessment.
Behavioral	Duration	Duration to collect the badges (complete review of each sub-topic).	The duration mean is 5.47 days compared to 14 days to use the prototype.	There is engagement through attention and persistence due to using the prototype in a short period.
	Motivation	Did level openings by completed sub-topics motivate you to finish the study?	100% answered Yes.	There is engagement through motivation due to the completed sub-topic.
	Focus	Does the length of time to answer questions make you more focused on answering?	100% answered Yes.	There is engagement through the focus given when answering the assessment.
Emotional	Fun	Does earning badges give you joy?	100% answered Yes.	Engagement through emotions shows fun, stress, enthusiasm, and satisfaction during learning activities using certain gamification elements.
	Pressure	Does trying to get full marks would make you pressured?	100% answered Yes.	
	Enthusiastic	Does getting full marks and being eligible to answer the assessment make you enthusiastic?	100% answered Yes.	
	Satisfaction	Are you satisfied with the use of this prototype?	100% answered Yes.	

TABLE VI. ENGAGEMENT MEASUREMENT THROUGH GAMIFICATION DESIGN

Assessment item	Worksheet item	Finding	Result
Segmentation	Are the notes provided precise and easy to understand?	100% answered Yes.	The appropriateness of gamification design is critical. It ensures optimal gain of the positive effects of gamification.
Feedback	Does feedback on wrong answers help you?	100% answered Yes.	
Educational games	Did you learn something even while playing?	100% answered Yes.	A more flexible gamification design is needed so students can take a break from the relatively dense and heavy learning content.
	Do you play while studying?	100% answered Yes.	

V. DISCUSSIONS

Based on the analysis enforced on two measurement instruments, gamification in TVET blended learning has proven to enhance student engagement during self-learning sessions. Student engagement during learning activities positively impacts students' learning experience, especially the emotions of fun that produce an effective learning environment. Subsequently, learning results increase through better student achievement than activities without gamification.

The main contribution of this study is to develop a mobile learning application prototype into TVET blended learning with gamification to increase the potential of involvement. The developed application prototype can be used as a reference and modified according to the suitability of learning in other TVET fields that emphasize competence from the aspects of knowledge, skills, and attitudes. Moreover, this prototype expects to help facilitate learning and provide additional reference resources for instructors and students.

Several previous studies also support the findings of this study. Gamification provides students a pleasant learning experience by encouraging comprehension, pleasure, and higher concentration. It promotes learning, lowers boredom, and enhances engagement, resulting in competitiveness and improved performance [27]. Students feel satisfied, have better interactions, stress and worry about the evaluation are lessened, and the generation's psychological requirements are met [28]. It boosts students' skills in discovering and solving complicated problems through simplified learning [8]. It increases student motivation as a stimulus for active participation in higher and continual learning performance. As a result, the dropout rate is reduced, particularly in the TVET context [29].

Even though gamification has a beneficial influence, several concerns must be addressed, particularly regarding long-term usage. For example, reducing students' motivation due to rules that prevent access to the next activity if they have not completed the previous one and notifications for completing incomplete activities or reaching a certain level [30].

VI. CONCLUSIONS

This study successfully created a gamified mobile app prototype to assess the effectiveness of gamification on student engagement in TVET blended learning. Gamification assists students in improving their achievement and having a better learning experience. The prototype can be used in related domains and extended to additional TVET fields as gamified learning resources to ease the current learning process.

This study encountered several limits, including a lack of research on gamification in the context of TVET blended learning environments compared to academic-based education. The limitation slightly disrupts the study flow to gathering the best and most useful reference materials. Next, mobile devices impact the delivery of learning materials because of the limited display size, which causes misunderstanding of simple statements by students, low-quality graphics due to small size, and the difficulty in maintaining uniformity, such as the size of texts and answer selection buttons.

In addition, the application prototype is limited to Android device users only. Application prototype development for other platforms such as IOS devices and websites needs different software or system settings. This process requires allocating a lengthened period and appropriate expertise to enable the prototype on various platforms.

Gamified prototypes have the potential to be expanded as an alternate technique for executing learning activities to enhance student engagement in TVET and other educational domains. Collaboration among diverse stakeholders such as instructors, universities, industries, and application developers is vital in maximizing gamification's benefits. As a result, future study recommendations presents as follows:

- The sample size of the students from the control and experimental groups increased, and the more extended period of the application prototype use to determine a more accurate measurement of potential engagement.
- Further research on more specific gamification elements and designs is needed as a measurement item to identify the existence of student engagement in detail.
- The study is extended through blended learning using gamification for students with disabilities in the TVET environment.

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